Research Journal of Agriculture and Forestry Sciences ______________________________ ISSN 2320-6063
Vol. **1(5),** 5-8, June **(2013)** *Res. J. Agriculture and Forestry Sci.*

Effect of Forest Fire on Microbial Diversity of the Degraded Shola Forest Ecosystem of Nilgiris Eastern Slope Range

Saravanan V.*, Santhi R., Kumar P., Kalaiselvi T. and Vennila S.
Dept. of Tree Breeding, Forest College and Research Institute, Tamil Nadu Agricultural University, Mettupalayam - 641301, TN, INDIA

Available online at: www.isca.in
Received 15th April 2013, revised 4th May 2013, accepted 28th May 2013

Abstract

The present investigation was carried out in the degraded shola forest ecosystem of the Nilgiris Eastern Slope Range situated in the Nilgiris North Division, Tamil Nadu, India to evaluate the effect of fire on the microbial diversity of the soil. Representative soil samples were collected at four different depths (0-15, 15-30, 30-45 and 45-60 cm) during four different seasons (summer, pre-rainy, post-rainy and winter) from both fire affected and unaffected areas of degraded shola forest ecosystem and were analysed for their biological properties. The bacterial population was 109.0 per cent higher in the burnt area as compared to the unburnt area. However, there was a reduction in the fungal and actinomycetes population to the tune of 31.4 and 75.0 per cent, respectively in the burnt area than the unburnt area. The conclusion drawn from the present study showed an increase in bacterial population and reduction in fungal and actinomycetes population.

Keywords: Forest fire, microbial diversity, bacteria, fungi and actinomycetes.

Introduction

A characteristic feature of the Nilgiri Biosphere Reserve is the occurrence of 'sholas' (Montane forests) above 1,500 m. They are found in patches, in hollows and sheltered folds surrounded by rolling downs in the Anamalais, Nilgiri and Palani hills and the high ranges of Kerala and Karnataka. Montane evergreen forests have thick undergrowth; the trees are short bolded and attain a low height of 15-20 m. The shola forest community had wider distribution in the past which has been established through pollen analytical investigations. Forest fire occurs in one or the other part of Nilgiri Biosphere (approximately 1,000 ha annually under heavy intentional fires), which not only retards the growth of existing vegetation but also not allowing new recruits to emerge out on the forest floor[1].

Srivastava[2] found that the major cause for the depletion and loss of biodiversity in the Nilgiris is the fire originating from human causes. The recurrent fire set by grazers during the summer dealt a severe blow to the floristic composition. It also increased erosion and altered the physical, chemical and biological properties of the soil converting organic ground covers to soluble ash and modifies the micro-climate through the removal of over head foliage. The soluble ash is washed away in the next rain. Fires can also make the trees more susceptible to insect attack. Simultaneously, the woody vegetation present in the grassland also disappears. The upper layer of the soil which is in the process of formation of humus gets badly affected and micro-organisms that play a vital role in the system get destroyed.

Though the incidence of forest fire is not a frequent phenomenon in the shola forest ecosystem which is known for its rich floristic diversity, it is frequent in the degraded sholas due to severe biotic interference. Hence, systematic experimental studies are needed to understand the effect of fire on the biological properties of the soil during different seasons. Forest fire in the degraded shola of Nilgiri Biosphere Reserve is very common every year. However, the impact of forest fire on the soil microbial properties has not been carried out so far. Keeping the above points in view, the present investigation was undertaken in the degraded shola forest ecosystem of Nilgiris Eastern Slope Range, Nilgiris North Division, Tamil Nadu, India with the following objective of i. assessing the effect of forest fire on the biological properties of the soil under degraded shola forest ecosystem and ii. evaluating the evaluate the effect of forest fire on the dynamics of soil microbial properties at different depths and seasons.

Material and Methods

The present study was carried out to investigate the effect of forest fire on the biological properties of soil of the fire affected area. The details of the field and laboratory studies conducted and the methods followed are presented here. The present study area is located between the latitudes 11° 26.272' North and 11° 26.516' North and the longitudes 76° 55.073' East and 76° 55.112' East of Kotagiri taluk in the Paravakkadavu Reserve Forest (271.387 ha) of the Kengarai beat which comes under the administration of Sholur Mattam section of the Nilgiris Eastern Slopes Range with an average elevation of 2000 m above MSL. Soil is generally acidic in reaction and the pH ranges from 5.0 to 6.5. The soil is classified into loamy brown which is rich in organic matter[3].

Estimation of microbial population: Soil samples were collected at 0-15 cm depth from the experimental site and analyzed for microbial population and enumeration was done using the serial dilution techniques of Parkinson *et al* [4]. Soil microbial analysis was done for enumeration of bacteria, fungi and actinomycetes population using serial dilution 10^8, 10^5 and 10^2, respectively and in appropriate medium (Nutrient Agar, Rose Bengal Agar and Ken Knights Agar) in sterile plates. The composition of each medium is given below. Enumeration was done after 24 hours for bacteria, 48 hours for fungi and six days for actinomycetes.

Composition of nutrient media used for soil microbial analysis: i. Bacteria-Nutrient Agar medium (g lit^{-1}): Peptone 5.0, beef extract 3.0, NaCl 5.0, agar 20 and distilled water 1000 ml, ii. Fungi- Martin's Rose Bengal Agar medium (g lit^{-1}): Glucose 10.0, peptone 5.0, KH_2PO_4 1.0, $MgSO_4$ $.7H_2O$ 0.5, rose bengal 0.33, agar 15.0 and distilled water 1000 ml. iii. Actinomycetes-Ken knight medium (g lit^{-1}): K_2 HPO_4 1.0, $NaNO_3$ 0.1, KCl 0.1, $MgSO_4$ $.7H_2O$ 0.1, glucose 10.0and distilled water 1000 ml.

Statistical analysis: The experimental data emanated from the present investigation were subjected to statistical scrutiny in order to determine the treatment effect and other factors[5].

Results and Discussion

Bacteria: The microbial population was found to be affected due to forest fire which could be observed by increase in the bacterial population in the burnt area on compared to the unburnt area. Significantly higher population of bacteria was noticed in burnt area. Their mean values were 44 x 10^8 CFU g^{-1} soil for unburnt and 92 x 10^8 CFU g^{-1} soil for burnt areas, respectively (table 1).

Among the seasons, post-rainy season (S_3) showed highest mean value of 122 x 10^8 CFU g^{-1} soil with respect to bacterial population followed by 91 x 10^8 CFU g^{-1} soil in pre-rainy, 41 x 10^8 CFU g^{-1} soil in summer and 18 x 10^8 CFU g^{-1} soil in winter season. The seasonal differences in the bacterial population were observed to be significantly different. However, the pre-rainy and post-rainy seasons were found to be on par and similarly summer and winter seasons were found to be on par with each other. The seasonal variation was also influenced by fire which was observed from the interaction effect. The highest mean value was 181 x 10^8 CFU g^{-1} soil in post-rainy season at surface soil under burnt area and the lowest mean value was 12 x 10^8 CFU g^{-1} soil in summer and winter seasons of unburnt area.

The bacterial population of the burnt areas was higher than the unburnt areas. This increase in the population of bacteria after burning may be due to the enhanced availability of N and K which was evident from the analytical results of soil samples collected during post-rainy season. The favourable microclimatic conditions viz., moisture content, temperature, active litter decomposition might have accounted for maximum bacterial action during post-rainy season. Similarly, Neal *et al* [6] reported that bacterial population increased after burning. But, the population was fluctuating with seasonal changes. Balagobalan *et al*[7] also reported that quantitatively the population of soil bacteria was more in burnt soils than in unburnt forest soils. The lowest population was registered during winter, due to psychrophilic temperature regime as most of the mesophilic microbes might have been under inactive stage, which was evident from the lab analysis.

The lower and higher bacterial population during summer and pre-rainy seasons, respectively might be due to differences in soil temperature. Similarly, Arcara *et al*[8] reported that the microbial population increased several times higher than that of comparable unburnt areas in the first season following fire and these counts thereafter decreased in successive seasons. Among bacteria, *Bacillus* was dominant in all depths after rainy season in burnt sites. Due to endospore forming capacity, the genus might have tolerated higher temperature and thus proliferated heavily after fire. This might have been the possible reason for its greater number over fungi and actinomycetes.

Table-1
Microbial population in the unburnt and burnt soils of the degraded shola forest as influenced by seasons

Area	**Bacterial population ($X \times 10^8$ CFU g^{-1} soil)**					**Fungal population ($X \times 10^5$ CFU g^{-1} soil)**					**Actinomycetes population ($X \times 10^2$ CFU g^{-1} soil)**				
	S_1	**S_2**	**S_3**	**S_4**	**Mean (B)**	**S_1**	**S_2**	**S_3**	**S_4**	**Mean (B)**	**S_1**	**S_2**	**S_3**	**S_4**	**Mean (B)**
B_1	12	90	62	12	44	95	112	142	135	121	15	13	16	21	16
B_2	69	92	181	25	92	57	64	100	113	83	3	1	7	3	4
Mean (S)	41	91	122	18	68	70	88	121	124	102	9	7	12	12	10
		B	S	B x S			B	S	B x S			B	S	B x S	
SEd		14	20	28			111	16	23			1	2	2	
CD (0.05)		30	43	61			24	34	NS			2	3	NS	

Fungi: The population of fungi in the unburnt areas was found to be higher than that of the burnt areas which could be well established from their mean values of 121 x 10^5 CFU g^{-1} soil and 83 x 10^5 CFU g^{-1} soil, respectively. In the case of seasonal variation, the winter season recorded higher value of 124 x 10^5 CFU g^{-1} soil followed by 121 x 10^5 CFU g^{-1} soil in post-rainy, 88 x 10^5 CFU g^{-1} soil in pre-rainy and 70 x 10^5 CFU g^{-1} soil in summer season irrespective of burnt and unburnt areas. The summer and pre-rainy seasons were found to be on par and similarly post-rainy and winter season were found to be on par. The pre-rainy and post-rainy seasons were also found to be on par with each other. The combined effect of season and fire on the population of fungi was statistically non-significant. The highest mean fungi population of 142 x 10^5 CFU g^{-1} soil was observed in the post-rainy season under unburnt areas and the lowest mean value of 57 x 10^5 CFU g^{-1} soil was recorded in the summer season under burnt areas.

The fungal population was reduced in the burnt area compared to the unburnt areas in comparison to the behavior of bacterial population. Since fungal spores are the main propagules for reproduction of fungi, elimination of spores during fire would have reduced the total fungal population in soils collected after fire. Renbuss *et al*[9] reported that fungal population growth was very slow in the burnt soil. Wright and Tarraunt[10] also observed decrease in soil fungal population after burning.

Even though soils collected during winter harboured more number of fungi in burnt plots, the difference between post-rainy and winter season was not significant. The fungal population was found to increase from the summer to winter season in ascending order which might be due to the return of favourable climatic conditions in the subsequent seasons and finally the population level of unburnt and burnt plots became equal in number as the season changed. Neal *et al*[6] also recorded a slight reduction in fungi throughout the first post-fire year and shortly afterwards, the numbers returned to the pre-burnt levels. Sankaran[11] observed a general decrease in fungal population after fire because of unfavourable conditions.

Actinomycetes: On comparative analysis, the actinomycetes population in this study area was found to be lower than that of bacteria and fungi. But, the unburnt areas recorded higher actinomycetes population than that of burnt areas which could be noticed from their mean values of 16 x 10^2 CFU g^{-1} soil and 4 x 10^2 CFU g^{-1} soil, respectively. The variation in the actinomycetes population among the unburnt and burnt areas was significant.

Similarly, the seasonal influence on the actinomycetes population was observed to be significantly different. The highest mean value of 12 x 10^2 CFU g^{-1} soil was recorded in post-rainy and winter seasons and the lowest mean value of 7 x 10^2 CFU g^{-1} soil was recorded in the pre-rainy season irrespective of the unburnt and burnt areas. The post-rainy (S_3) and winter (S_4) seasons were found to be on par and so was the case with summer (S_1) and pre-rainy (S_2) seasons. On the contrary, the interaction effect of burning and season on actinomycetes population was observed to be non-significant. The highest mean value of 21 x 10^2 CFU g^{-1} soil was noted in winter season under unburnt area (B_1S_4) and the lowest mean value of 3 x 10^2 CFU g^{-1} soil were recorded in summer and winter seasons of burnt area simultaneously (B_2S_1 and B_2S_4). However, the difference among the mean values was only numerical.

As in the case of fungal population, the actinomycetes population also recorded a significantly lower population in burnt areas as compared to the unburnt areas due to the effect of burning on spore formation. It is perceived that the heat generated in the soil during the burning, might have inhibited the spore formation and also eliminated aerial spores. Accordingly, Renbuss *et al*[9] reported that the recolonization of actinomycetes in the burnt soil was slower.

In summer season immediately after fire, the actinomycetes population was found to be low due to adverse environmental condition and then the population increased during winter season due to the return of favourable environment. Similarly, Srivastava[12] reported that the actinomycetes population was higher during winter season when compared to all other seasons. Fungal and actinomycetes population got reduced heavily after fire. Unlike bacterial endospores, spores of these two organisms could not tolerate higher temperature. Hence, the population reduced drastically after fire due to poor reproductive propagules.

Conclusion

Fire affected areas of degraded shola forest ecosystem brought out the following changes in the biological properties of soil (i.e) increase in bacterial population and a decline in fungal and actinomycetes population. The microbial population varied widely in burnt and unburnt areas. The bacterial population was 109.0 per cent higher in the burnt area compared to the unburnt area due to the pronounced impact of fire on the soil properties. Comparatively fungal population was 31.4 per cent decreased and actinomycetes population was 75.0 per cent decreased in the burnt areas than the unburnt areas. With regard to the seasonal influence, the highest and the lowest bacterial population was recorded during post-rainy and winter seasons, respectively; winter and post-rainy seasons showed the highest fungal and actinomycetes populations over other seasons.

Reference

1. Srivastava R.K., Forest fire and its prevention by generating environmental awareness in the rural masses, World Forestry Congress, Turkey **(1997)**

2. Srivastava R.K., Forest fire and biotic interference – A great threat to Nilgiri Biosphere, *Indian Forester*, 667-673 **(2002)**

3. Somasundaram K., Working plan (Part I, II and II) for the Nilgiris North Forest Division, Tamil Nadu Forest Department **(2005)**

4. Parkinson D., Gray T.R.G. and William S.T., Methods for studying the ecology of soil microorganisms, Oxford; Black Well Scientific Publications, 116 **(1971)**

5. Sukhatme P.V. and Amble V.N., Statistical methods for agricultural workers (Rev. Edn.), ICAR, New Delhi **(1985)**

6. Neal J.L., Wright E. and Bollen W.B., Burning Doughlas fir slash, physical, chemical and microbial effects on the soil, *Oregon State Univ. For. Res. Lab. Paper,* **1,** 32 **(1965)**

7. Balagobalan M., Menon A.R.R., Surendran T., Mohan C. and Rugmini P., Ecosystem dynamics in relation to fire in different forest types, *KFRI Research Report No. 235*, Kerala Forest Research Institute, Peechi, 73 **(2002)**

8. Arcara P.G., Buresti E. and Sulli M., Indagini sugaliincendi in foresta: previsioni del rischioe misura deg li effectii sul suolo tranite saggi microbiologici, *Ann. Inst. Sper. Selvic.,* **6,** 75-120 **(1975)**

9. Renbuss M.A., Chilvers G.A. and Pryar L.D., Microbiology of an ash bed, *Proc. Linn. Soc. N.S.W.,* **97,** 302-311**(1973)**

10. Wright E. and Tarraunt R.F., Microbiological soil properties after logging with slash burning, *U*.S. For. Serv. Pal. NW. For. Range Exp. Stn. Res. Notes No. **157 (1957)**

11. Sankaran K.V., Effects of prescribed burning on soil microflora and litter dynamics in a moist deciduous forest ecosystem of Western Ghats, KFRI Research Report No. 235, Kerala Forest Research Institute, Peechi, 52 **(2001)**

12. Srivastava R.K., Impact of forest fire on ecotone zone of shola-grassland ecosystem, Ph.D. Thesis, Forest Research Institute, Deemed University, Dehra Dun **(2001)**